FOREST HEALTH PROTECTION
Pacific Southwest Region

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Biological Assessment of White River Campground, White River Housing Tract, Redwood Meadow Campground, and Trail of 100 Giants, Western Divide Ranger District, Sequoia National Forest

Introduction & Background

For the past few years, insect and disease activity on the Western Divide Ranger District has very noticeable. Mortality and damage caused by both bark beetles and pathogens in both pines and firs have been observed in various locations throughout the district – some in high use recreation areas. Much of the mortality has occurred among larger diameter trees, particularly the pines. Four locations on the district have had ongoing pest issues that are altering the forest structure and its natural aesthetic, but more importantly creating hazardous conditions for the public. Dead trees in campgrounds and other administrative areas are considered hazardous if there are identified targets within range.

Forest Health Protection, South Sierra Shared Service Area made two visits to the district focusing on four primary locations: White River Campground (Township 24 S, Range 31 E, Section 16), White River Summer Housing Tract (Township 24 S, Range 31 E, Section 14), Redwood Meadow Campground (Township 22 S, Range 31 E, Section 35), and Trail of 100 Giants (trailhead) (Township 22 S, Range 31 E, Section 35). The White River Campground and housing tract are located below the Hot Springs work center, along White River. Redwood Meadow campground is located directly across from the 100 Giants trailhead, along the Western Divide highway (County road 107). Except the housing tract, these sites are amongst the highest used recreational areas on the district, drawing thousands of visitors annually. During the summer months campsites and parking lots are often fully occupied. Housing tract residents are intermittent but stay longer when present.

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Recent bark beetle activity resulting in loss of many legacy-sized trees in these recreational areas has caused safety hazards and concern over additional loss of mature pine. George Powell (District Ecosystem Manager) requested a biological assessment of these special locations to identify causes for the recent mortality, and suggestions for possible management strategies to retain remaining large diameter (>30 inches) trees while promoting healthy stand conditions to minimize further loss. This report documents Forest Health Protection (FHP) observations and data taken on July 15 & 16, 2009; management options are included in the discussion.

Observations and Current Stand Conditions

A. White River Campground. The campground proper is about 20 acres in size with an additional dispersed area (3 acres) adjacent to the river. Stand composition and type were fairly similar at both the White River Campground and White River Housing Tract. They are located along White River less than one mile apart, at the same elevation of 4200 feet. Current stand composition was comparatively balanced between ponderosa pine, white fir, and incense cedar in the dominant to co-dominant crown classes. Ponderosa pines comprised most of the larger diameter stems (ranging 15 to 50 inches, average 25 inches); white fir and incense were smaller at 9 to 28 inches (average 12 inches) in size. Singular mature black oaks were found scattered throughout the campground, many dwarfed by overstory conifers. Stands were naturally widely spaced where ponderosa pine was the primary component – mostly along the river bed. Canopy cover was also open, and brush vegetation was moderate.

Elsewhere, such as within and between campsites, incense cedar was prolific. Incense cedar comprised over half of the campground trees, with some areas nearly pure incense cedar. Around campsites, canopy closure neared 100%. Pine or fir regeneration was nearly nonexistent due to the density of incense cedar regeneration. However, trampling and cattle browsing of the less shade tolerant pines have also impacted pine regeneration. Limited open growing space presumably retarded pine establishment. However, minimal ground vegetation or regeneration of any species was tallied *in* campsites (see Figure 1). Where regeneration was found in open (pine) stands, regeneration was 90% incense cedar. Similar stand conversion to incense cedar also appeared to be occurring in general forest outside the campground. Basal areas taken in various spots in the campground ranged from 340-450 ft^2/acre.

The density of cow dung piles observed in the housing tract and campground areas imply additional browsing pressure by cattle. This observation would help explain the dominant regeneration was of the less palatable incense cedar. A brief survey gave an estimate of one pine seedling for every 50 incense cedar seedlings. However cedar is more shade-tolerant than pine, and must be a part of the explanation for the dominance of cedar. After observing where there was good cedar regeneration, most of the seedlings had come up adjacent to a post or obstacle. It was estimated that for every seedling that had become established in the open, four had become established within a foot of a wooden post.

Figure 1. Pure Incense cedar stand, campsite 4 in the White River Campground. Note: no regeneration in the understory due to heavy visitor foot traffic.

Figure 2. A group of Incense cedars established next to posts.

Figure 3. More Incense cedars established next to posts (Red arrows).

If planting is to be considered, then seedling protection should also be implemented; efforts may be futile if trampling or grazing is allowed to continue. (*To view a PowerPoint that was drawn up from the images taken at the White River camp ground please consult the FTP website (ftp://ftp.r5.fs.fed.us/pub/stanislaus/pub/) and open the file entitled "Planting on Rec Sites."*)

Upon examining a large incense cedar by the campground entrance, a conk of ***Oligoporus amarus***, the cause of pocket dry rot, was observed (Figure 4). Without having a Resistograph™ to core this tree it is not possible to say definitively that this tree is a risk to campers. However, based on experience with this type of decay it is not normal for this species to fail from this kind of decay, at this stage in the host's lifecycle. This tree should be annually monitored, and as soon as is possible FHP will check this tree using the Resistograph™. Any dead hazard trees in the campground should be removed at the first possible opportunity and definitely before the 2010 camping season.

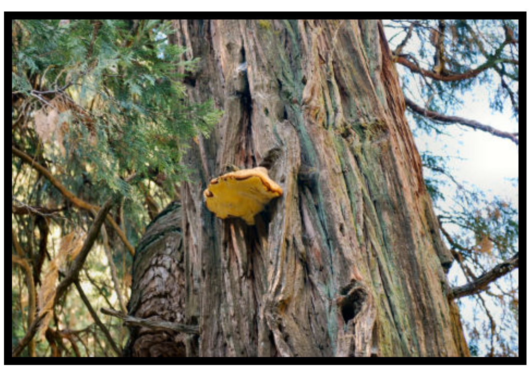

Figure 4. Conk of ***Oligoporus amarus*** on incense cedar, indicator of dry pocket rot.

Armillaria root disease. Armillaria species in California have an unusual characteristic: if they are growing pathogenically on an oak host and the host dies, they can become pathogenic on surrounding conifers. It has been well documented in Yosemite National Park, Armillaria fungus has grown out from a fallen oak and attacked surrounding conifers. Similarly on the Sequoia National Forest (observed in the Whitaker Plantation, Hume Lake Ranger District) when a black oak was felled, the fungus became pathogenic on an adjacent giant sequoia. Upon death of its oak host, the fungus apparently grows out from the oak and infects adjacent conifers if another oak is unavailable. While oak is the preferred host in California, this fungus species is omnivorous. For this reason we recommend minimal to no oak removal if possible and radial thinning around oaks is also recommended to reduce inter-tree competition.

A. Recommendations for the White River campground.

- Remove all dead standing trees.
- Monitor annually all campground trees for their hazard potential.
- Monitor cedars known to have some level of pocket dry rot.
- Avoid cutting (if possible) any black oaks in the campground, as doing so will stimulate the development of pathogenic Armillaria attack of residual conifers.

B White River Summer Housing Tract. This small housing tract is made up of 20 small houses that lie along the river except for two (houses #5 and 6). Wooden bridges are used at access the houses by foot or car, and resource damage of the river appears minimal from use. Stand composition here is also pine, fir, and incense cedar, with incense cedar dense in the understory regeneration.

There was evidence that a group of ponderosa pine mortality that was estimated to have occurred in 2006 had been felled and cut up. One of the first trees killed was in the river bed with attached phone lines. When the tree snapped the proceeding winter, the tree dragged down nearby attached-line trees causing additional damage to live trees. A homeowner mentioned it was just after this event that the utility company installed a free standing pole but did not move existing lines on live trees. The recent damage associated with attached wires on live trees in White River housing tract could have been prevented if wires had been moved to free-standing poles. It was observed that some of the attachment points for wires were constricting tree growth. The current setup of wires in the housing tract will complicate any stand treatments and may cause future tree failures. It would be preferred that future tree felling contracts contain a cautionary statement concerning attachment of overhead wires.

It appeared that fuels reduction efforts were recently implemented surrounding the housing tract, generally removing all trees less than 9 inches then piling slash for later burning. This effort did reduce fuel loads to prevent severe wildfires, but only reduced basal areas slightly from current estimates within and around the housing tract (range 280 to 350 ft^2/acre). Basal areas and stem counts surrounding houses were much higher, most likely intentionally left for screening and aesthetic purposes.

B. Recommendations for the White River Summer Housing Tract.

- Remove all dead standing trees.
- Monitor the tract annually for hazard trees.
- Avoid cutting black oaks; doing so will stimulate the development of pathogenic *Armillaria* attack of residual conifers.
- Encourage utility companies and homeowners to stop (and even remove current) attachments to living or dead trees.

C. Redwood Meadow Campground (including day-use parking lot) & Trail of 100 Giants (trailhead). These sites are located around 6000 feet in elevation with Sugar pine, Jeffrey pine, and Giant Sequoias replacing ponderosa pine. Pines comprise 55% of the overstory, incense cedar and white fir in the remaining 40%. Black oaks and Giant sequoias were less than 5%. Giant sequoias – the big ones – were clumped in groups, and younger trees were found randomly along the trail. Only one small sequoia was found in the campground, near the entrance. Within the campground, trees were tightly clumped in small islands or unevenly spaced at campsites. Stand structure were mainly mature pines bunched with smaller diameter incense cedars and firs (see Figure 5). There were some larger firs and incense cedars, but the stands appeared to have been historically pine dominant. Basal areas in the campgrounds ranged widely from 200-400 ft^2/acre due to the mix of campsites, islands, and surrounding forest.

Figure 5. Clumpy distribution and uneven-aged trees in Redwood Meadow Campground; paved roads encircle the island.

Immediately outside recreation perimeters, thickets of white fir grew – about 25 stems per 1/20th acre, average diameter of 6 inches (see Figure 6). Since 2006, over ten 30-inch-plus sugar and Jeffrey pines had been bark beetle killed, then removed for public safety. An additional two sugar pines (51 and 59 inches) in campsite #4, two white firs (17 and 24 inches) were successfully attacked in 2008. Tree loss has altered canopy cover in those microsites, leaving the area significantly open with no pine regeneration underneath. The pattern of mortality is appears to be concentrated in the tight tree clumps or heavy public traffic areas rather than in overstocked areas, like those surrounding the campground. This pattern of mortality is best seen in Figure 7: red arrows indicate cut stumps and blue arrows indicate replacement incense cedars. Within a 30 ft radius circle, 15 stumps were counted (mostly pine) while all five remaining live trees were incense cedars.

Looking upwards, the crowns of some of the surviving Sugar Pines appeared to be suffering from infections by the White Pine Blister Rust fungus. It is surmised that the additional stress of blister rust, predisposed by visitor foot traffic, high stem densities, or recent droughts led to eventual attack by mountain pine beetle.

Figure 6. Dense white fir regeneration surrounding mature incense cedars and pines in surrounding stands immediately outside of Redwood Meadow Campground.

If stand conditions remain unchanged, other large trees in adjacent areas will begin to decline too.   To prevent this scenario, a radial thinning around the largest legacy trees to remove most of the smaller trees of < 20 inches is strongly encouraged. Radial thinning will remove smaller trees that are intercepting and utilizing water that would otherwise be available to the larger legacy, trees. As a consequence of the water competition, larger trees are more susceptible to insect and disease attacks. In the past FHP has recommended radial thinning out to the drip line or 50 ft, whichever comes first. In a campground, radial thinning will eliminate much of the visual screening the small trees provide. Given the value of the increased vigor of legacy trees FHP believes that the loss of screening is an acceptable alternative.

Silvicultural treatments that reduce resource competition and heavy fuel loading while improving stagnant microsite conditions also aid in preventing bark beetle infestation. Density management promotes overall healthy stand conditions while alternatively creating unsuitable conditions for bark beetles (Forest Health Protection 2007). Vigorously growing trees are less attractive to beetles; water stressed, pathogen infection, or other damages contribute to bark beetle risk. Stressed trees have weakened defenses to repel attacking beetles, thus being overcome by mass attack. For areas like campgrounds where stands are primarily uneven-aged, adjusting stand density indexes or basal areas for each diameter classes is suggested to retain larger trees and prevent bark beetle mortality (Cochran 1992).

At campsite #11, symptoms of a laminated rot were identified in two very old fir stumps. This kind of delaminated wood is typically indicative of Annosum root disease (*Heterobasidion annosus*), but could not be confirmed from this location. Hence we urge the District to follow the current Regional Guidelines and apply Sporax® to any cut stumps generated in a radial thinning.

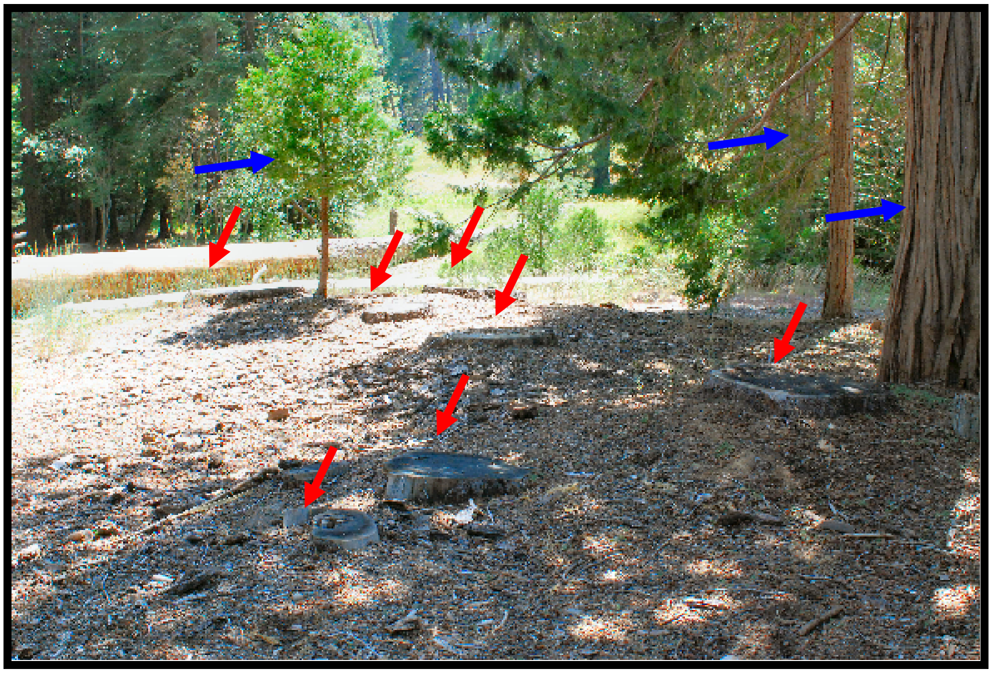

Figure 7. Red arrows indicate stumps of recently felled pines, and blue arrows indicate replacement incense cedars in Redwood Meadow Campground.

While White Pine Blister rust was observed (see Figure 8), it is not yet considered to be a primary killer of the large trees. However, this rust is an additional stress that makes infected trees vulnerable to bark beetle attack. Also, if trees are also exacerbated by drought or soil compaction, this fungus could cause direct mortality.

White firs, which were suffering from light leafy mistletoe infestations, were not suffering from dwarf mistletoe infections. There is no need for mistletoe pruning. Here again, parasitic plants are playing role secondary to drought and bark beetles that are also compounded by density issues. Reduced stocking will relieve much of the stress on the trees, making them more able to withstand infections by parasitic plants and fungi.

Figure 8. Sugar pine with branch dieback and red branch "flags" typically indicative of White Pine Blister Rust.

Rehabilitation is difficult, but can be implemented if effort is made to restrict visitors until sites have progressed enough to withstand the traffic. While sites may look “park-like”, regeneration in this setting does not establish frequently because seedlings get trampled. If and when trees die, replacement is unavailable. Eventually sites become barren openings that encourage visitors to migrate to covered spots – often resulting in larger and larger open areas (see Figure 9). Barriers or paths may guide visitors away from sensitive areas while still enjoying scenery. It is for this reason that we suggest using the logs (see Figure 10) to provide planting site protection seen. Long-term vegetation planning in these campgrounds is needed if the desired objectives are to retain overstory cover while maintaining stand diversity.

Figure 9. Open park-like spacing at Redwood Meadows day-use area.
Note: soil is bare mineral, minimal regeneration present.

If retention of current species composition and structure are also preferred, then planting and tree protection is strongly recommended. Giant Sequoias, sugar, and Jeffrey pines may need to be planted and protected to successfully establish in the Redwood Meadow and White River campgrounds. The clumpy grouping of trees in the campground is not conducive to pine regeneration and severely aggravates resource competition between trees. Reducing canopy closure or creating large openings in dense incense cedar pockets may encourage pine at White River Campground. If pines or fir are not able to escape through incense cedar regeneration thickets, stand conversion is imminent.

Campgrounds are notorious for irregular spacing and poor growing conditions for forest trees. Injury in any form can provide pathways for pathogen infection, lower tree resistance, or create additional unnecessary stress. Visitors unknowingly harm trees with nails, axes, or other mechanical damage. Visitor foot and vehicular traffic constantly trample developing seedlings, compact soil, and damage fragile root systems. Besides silvicultural strategies, public education for tree protection should be made available to visitors to understand the consequences of

particular actions. For this reason we are suggesting that explanatory posters be made up and posted on the public notice boards in campgrounds. Forest Health Protection can provide information or assistance with this task.

Figure 10. Jeffrey pines killed by bark beetles. Logs could potentially be used as structural barriers to increase upcoming seedling survival.

C. Redwood Meadow Campground (including day-use parking lot) & Trail of 100 Giants (trailhead).

- Remove all dead standing trees.
- Monitor the tract annually for hazard trees.
- Avoid cutting (if possible) any black oaks in the tract, as doing so will stimulate the development of pathogenic Armillaria attack of residual conifers.
- Radially thin around legacy pines in dense areas of the campground.
- Apply Sporax® to all cut stumps greater than 2 inches.
- Use take down trees to provide barriers to public access and use them to generate relatively trample proof planting sites.
- Replant with a mixture of species, preferably blister rust-resistant sugar pine stock.
- Generate posters for the public notice boards that explain the need for tree removal and ask the public to respect the growing seedlings.

D. Agents of Forest Change.

*Bark Beetles***.** Native bark beetles are a primary mortality agent of pines in western forests. Weakened, stressed, or diseased trees are most susceptible to beetle attack. When host defense mechanisms and overall vigor are compromised, trees become highly vulnerable to successful bark beetle infestation. Mortality caused by insects benefit local ecosystems in the creation of wildlife habitat, minor stand disturbance, or gap openings for new tree establishment. However continual loss of desired trees can also contribute to heavy fuel loading, public hazard, or interfere with administrative objectives for the site.

Sugar pines in the White River drainage and Redwood Meadow Campground are currently being infested by mountain pine beetle (*Dendroctonus ponderosae).* Foresters have noted that sugar pines fare poorly when conditions become too crowded, displaying symptoms of decline such as thinning or yellowing of crowns. Recent mortality in the southern Sierra Nevada of sugar pines has been found with little to no oleoresin streaming from attacked trees. Recent ground surveys by FHP have noticed that mortality has been of singular legacy-sized pines. Overcrowding is suspected to have weakened pines in Redwood Meadow campground resulting in past beetle attacks.

Western Pine Beetle (*Dendroctonus brevicomis*) favors severely stressed ponderosa pine, typically killing in small groups. Mortality from western pine beetle may continue if stand and weather conditions are favorable for attack. Five large diameter Ponderosa pines were successfully mass attacked in the White River Campground adjacent to day-use parking spots and campsite #2; estimated killed as early as 2006, one in 2008 (average DBH 26 inches). New attacks were not detected in surrounding hosts during the visit, but current stand densities were estimated to be at risk for further mortality. The widespread bark beetle outbreak that occurred in the San Bernardino Mountains in Southern California from 2003-2005 was partially western pine beetle killing large-diameter pines. Severe drought and overstocked stand conditions were ideal for beetle population expansion, green healthy trees that otherwise would have resisted normal beetle attack were quickly overwhelmed.

Jeffrey pine beetle (*Dendroctonus jeffreyi)* specifically targets Jeffrey pines. Jeffrey pine mortality due to JPB along the western divide corridor has been slowly increasing in recent years, most notable in the 100 Giants recreation area. JPB appears to prefer larger diameter hosts, slowing removing dominant seed trees from the stand. Jeffrey pine in Lake Tahoe Basin Management Unit historically experiences mortality surges from JPB nearly every decade and is currently experiencing a widespread outbreak in along the southern shores.

Fir engraver (*Scolytus ventralis*) activity was found in two white firs at Redwood Meadow campground. Fir engraver attacks often occur in overstocked stands or Annosum root disease pockets. Fir engraver respond to volatiles emitted by stressed host trees, rather than aggregation pheromones like *Dendroctonus* species (Macias-Samano *et al*. 1998). This would explain surges in engraver activity coinciding during times of low annual precipitation (Felix 1971). Thereby prediction of preferable hosts can be difficult, but presence of root disease or dwarf mistletoe (Felix 1971), or previous top-kill by engraver increases the likelihood of successful mass attack regardless below of size.

D. Bark Beetles: Management Alternatives.

Prevention strategies. Bark beetles infest singular and groups of trees, but maintaining overall stand health provides additional protection against continual attack on residual trees, pathogen infection, and resilience during stressful times (i.e. drought). Fettig et al.(2007) repeatedly determined that stands with higher stand densities were at greater risk for infestation to bark beetles in western states. In California, research conducted by Oliver (1995) had demonstrated heavy mortality when stand density indexes exceeded 365 for ponderosa pines. As basal area also increases, likelihood of attack increases even when pines (or other host species) are a small proportion of the composition. Thinning overstocked areas will reduce resource competition and significantly improve tree vigor and resistance against opportunistic mortality agents (Forest Health Protection 2007). Understandably, recreation areas are very unique microcosms in the forest, so thinning strategies can be specifically designed to prevent large-scale or undesirable mortality, especially in areas where older legacy trees are rare.

High-value trees can be pre-sprayed with a currently registered insecticide (e.g: the carbaryl-based Sevin®), but this option is costly and provides temporary protection for only two years or less. Prevention against bark beetle infestation can be implemented at the stand level, but more effective if applied at the landscape scale. Management of campgrounds and housing tract should incorporate the surrounding forest and topography. Creation of mosaic patterns with age, size, or host type will help reduce long-term susceptibility to forest pests, while encouraging resiliency during other disturbance events such as wildfires (North *et al.* 2009). While clumpy spacing may have contributed to tree stress in these areas, it can be beneficial when diversifying landscape conditions and promoting heterogeneity.

E. No Action Alternative. Singular and group mortality associated with bark beetles will likely continue in these areas primarily due to increasing stand densities. Visitor direct/indirect injury is weakening trees, thereby increasing their susceptibility to attack. However, this form of stress is not as severe as resource competition between trees. Abundant regeneration and stem densities of incense cedar along the White River is causing overcrowding and shading out of pines, fir, and oaks. Average basal areas for pine types in the campgrounds exceed risk thresholds predicted for imminent bark beetle attack (Oliver 1995). Beetle-associated mortality is most likely to continue in trees weakened by dwarf mistletoe, root disease, poor site conditions, limited resources, or recent drought events. If pathogen infections are severe, hosts may die outright or from windthrow breakage.

Forest Health Protection supports management strategies that prevent bark beetle infestation and promote healthy forests. Campgrounds are of particular concern due to high public use and visibility. FHP can provide assistance with vegetation planning, public information, and funding opportunities for projects that would be applied at the landscape scale or high-value individual tree protection. Please contact Forest Health Protection, South Sierra Shared Service Area if further assistance is requested.

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